OHIO RIVER BASIN PRECIPITATION FREQUENCY PROJECT

Update of *Technical Paper No. 40, NWS HYDRO-35* and *Technical Paper No. 49*

Seventeenth Progress Report
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DISCLAIMER

The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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1. Introduction

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for the Ohio River Basin and surrounding states. Current precipitation frequency estimates for this area are contained in *Technical Paper No. 40* "Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years" (Hershfield 1961), *NWS HYDRO-35* "Five- to 60-minute precipitation frequency for the eastern and central United States" (Frederick et al 1977) and *Technical Paper No. 49* "Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States" (Miller et al 1964). The new project includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The project will determine annual all-season precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The project will review and process all appropriate rainfall data for the project area and use accepted statistical methods. The project results will be published as a Volume of NOAA Atlas 14 on the Internet with the additional ability to download digital files.

The project will produce estimates for 13 states. Parts of nine additional bordering states are included to ensure continuity across state borders. The core and border areas, as well as daily and hourly regions now used in the analysis, are shown in Figures 1 and 2.
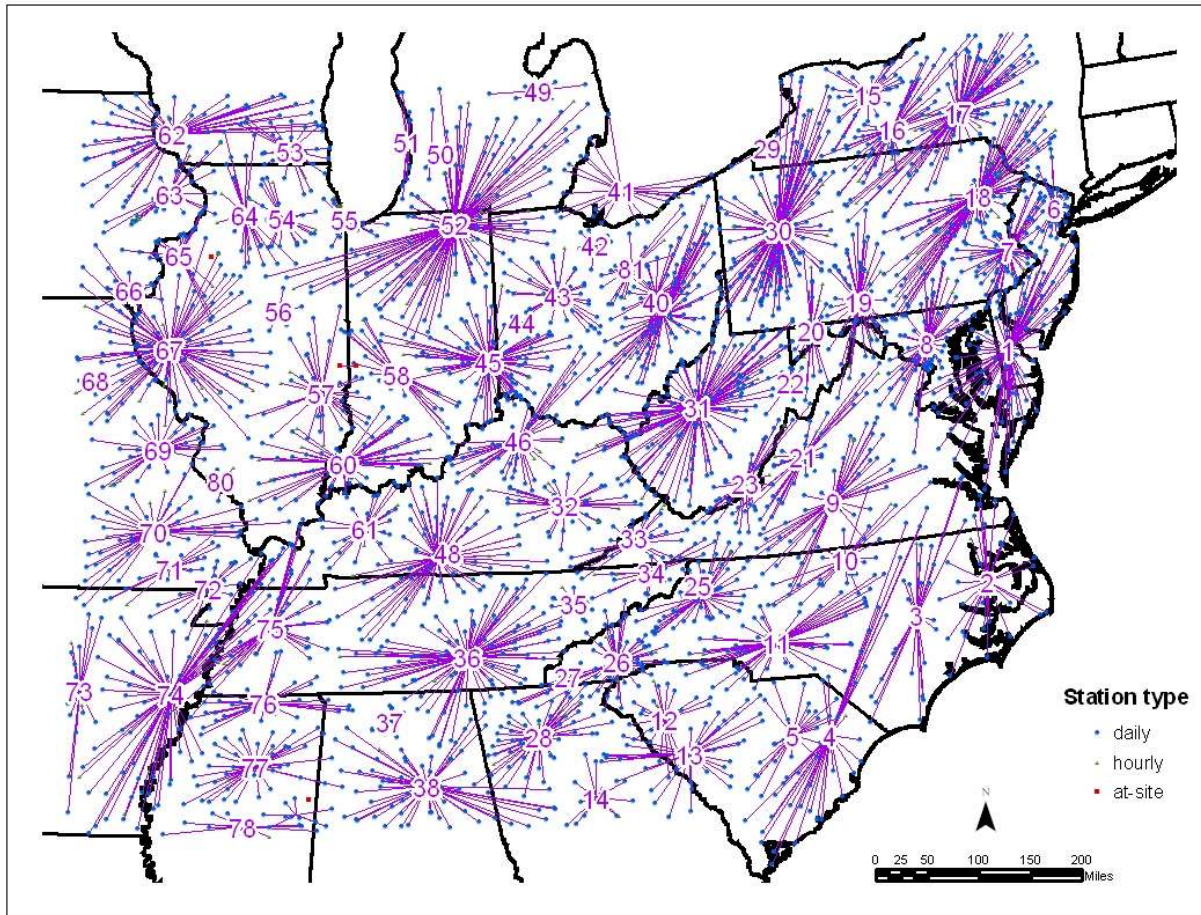
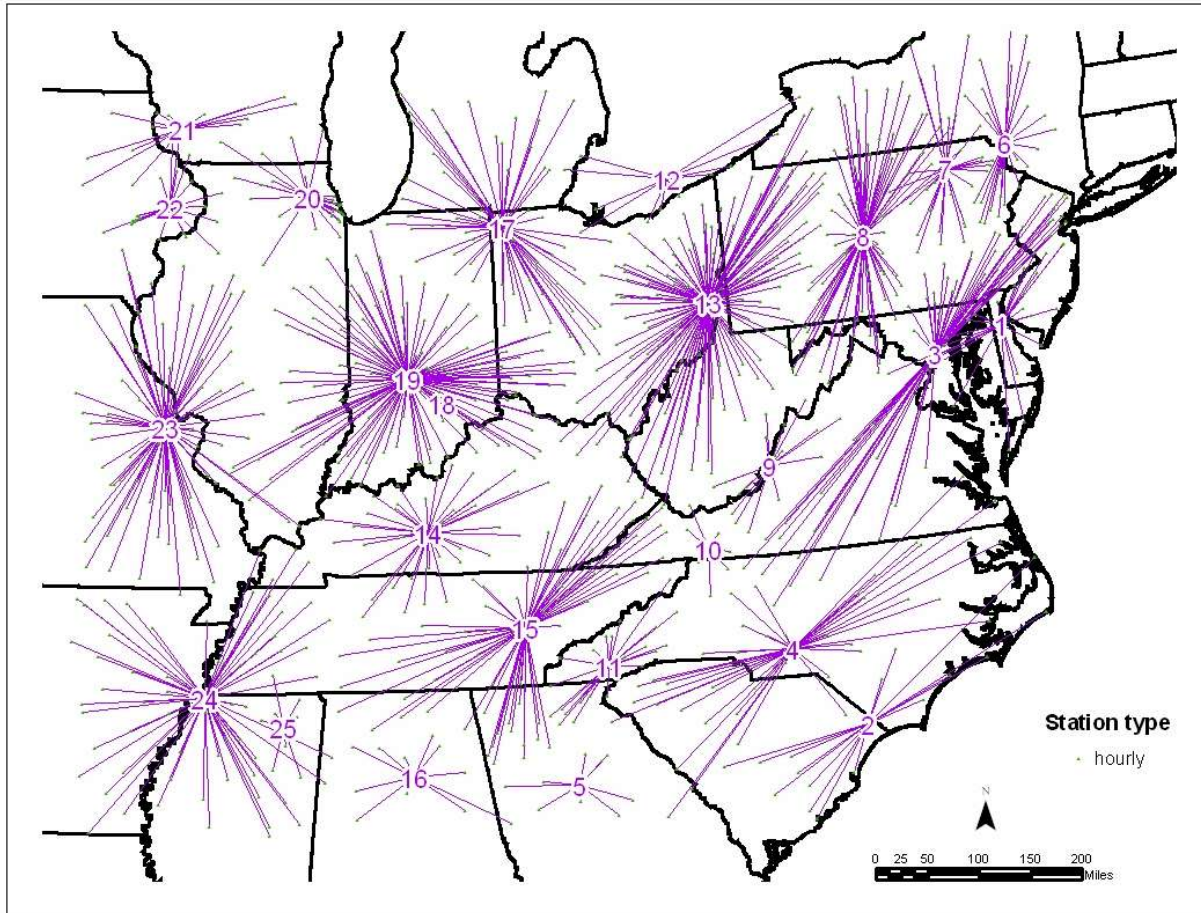Figure 1. Ohio River Basin project area and 81 daily regional groups.

Figure 2. Ohio River Basin project area and 25 hourly regional groups.

2. Highlights

Inconsistencies where an annual maximum of a shorter duration was greater than longer durations in a given year were corrected. Cases where the maximum observed amount for a longer duration (ie, 2-day through 60-day) exceeded the 1000-year estimate are being checked for data quality issues. Driven primarily by comments from the Peer Review, various methods are being explored to mitigate spatial bull's eyes. Additional information is provided in Section 3.1, Data Quality Control.

All L-moments and confidence limits were re-run after making minor regional and/or data corrections. Additional information is provided in Section 3.2, L-moment Analysis.

A procedure for adjusting mean PRISM grids was developed and tested. The Cascade, Residual Add-back (CRAB) derivation procedure was modified to accommodate a conversion from AMS-based results to PDS-based results. Additional information is provided in Section 3.3, Software Updates/Spatial Interpolation.

The Precipitation Frequency Data Server (PFDS) underwent several modifications. In particular, the results provided by the PFDS will now be in terms of partial duration series as the default, rather than annual maximum series. Additional information is provided in Section 3.4, Precipitation Frequency Data Server.

Study areas to be used and tested in the areal reduction factor (ARF) development have been selected and are being quality controlled. Software development to process the data and ultimately generate the ARF curves is 90% completed. Additional information is provided in Section 3.4, Areal Reduction Factors.

3. Progress in this Reporting Period

3.1 Data Quality Control

3.1.1 Annual Maxima Consistency Adjustment

Inconsistencies where an annual maximum of a shorter duration was greater than longer durations in a given year were corrected. This can happen when average adjustment factors that account for different sampling intervals are applied (e.g. 24-hour vs. 1-day data). It can also happen when the data has too many missing values immediately adjacent to the accumulation period of the shorter duration for the longer duration to be extracted. 17 cases where the difference was more than 10% were inspected and corrected for any data quality issues. The 10% cutoff was chosen as a convenient indicator above which the cause is generally missing data. Data at offending stations were corrected in daily regions 5, 6, 9, 11, 13, 16, 18, 19, 21, 30, 62, 67 and 76. If the difference was small (<10%), the longer duration annual maxima was set equal to the shorter duration for that year.

3.1.2 Longer Duration 1000-year Real Data Check Issues

In the real data check (RDC), cases where maximum observed durations exceed the 1000-year precipitation frequency estimate are carefully considered. The number of RDCs increased with increasing duration (from 28 at 24-hour to 223 at 60-day), in part because the regions were derived primarily using 24-hour duration data. It was decided not to pursue further mitigating procedures, such as subdividing based on longer durations or applying different distributions to different durations, for a number of reasons including the following:
1. The current regions are statistically homogeneous for the longer durations.
2. 1000-year estimates are very unstable given the limited data available.
3. In our analyses, annual maximum durations are defined as X number of sequential days in which the most amount of rain fell in a given year, which means that a given longer duration may include parts of storms or more than 1 storm event.
4. Given the number of stations in the project (>2500) with an average of 55 years of data, one might expect to find as many as 174 1000-year RDC events at each duration.
5. The RDC events are spatially scattered in regions randomly, indicating no systematic inadequacy.

Confidence limit software was modified to flag cases where the maximum observed value at a station exceeded the upper limit. In particular, RDC cases that exceed the upper limit are being carefully investigated for data quality issues

3.1.3   Spatial Bull's Eyes

The Peer Review of the 100-year 24-hour and 100-year 60-minute maps indicated that a major concern of users is insufficient spatial smoothing that allows bull's eyes in the spatially-interpolated maps.

In a preliminary investigation, a total of 46 major and minor 100-year 60-minute bull's eyes were examined. The main drivers of these spatial artifacts are:
1. a bull's eye in the mean occurred due to the spatial interpolation process of the mean grids or due to data sampling of particularly dry or wet periods at a station
2. a bull's eye in the quantile occurred due to the co-located adjustment applied to a station that has both hourly and daily data occurring in different regions than neighboring stations

Various methods are being explored to mitigate the 60-minute spatial bull's eyes. Possible solutions include increasing the spatial smoothing of the base mean maps as derived by PRISM technology at the Spatial Climate Analysis Service (SCAS) at Oregon State University or applying additional adjustments/smoothing techniques to the quantiles to account for co-located stations in different regions. Additional smoothing techniques are being explored to resolve the 24-hour bull's eyes that result primarily from data sampling.

3.2   L-moment Analysis

All L-moment statistics, confidence limits and final adjustments were re-run after making minor station corrections. Data corrections and adjustments were completed based on the annual maxima consistency check (see Section 3.1.1, Annual Maxima Consistency Adjustment).

Also, 11 stations were evaluated to ensure they were in the correct homogeneous region with respect to their geographic location. Corrections affected regions 1, 6, 13, 28, 39, 65, 67, 74, and 76. The edits did not greatly impact the quantiles of the affected regions. In the biggest change, a new region was formed from the northern section of daily region 39 creating a total of 81 daily regions (see Figure 1).

3.3   Software Updates/Spatial Interpolation

In the Semiarid Southwest Precipitation Frequency Project, we learned that slight changes may occur in the mean values due to data quality corrections. Since it is not always cost effective to have the Spatial Climate Analysis Service at Oregon State University re-run the grids with our updated data, we have developed a process to adjust the PRISM mean annual maxima grids.

The procedure starts with the calculation of an adjustment factor: new mean divided by old mean at each station. Here the old mean is the mean that was used in creating the original PRISM mean grid. Both means are from the database and not interpolated from the PRISM mean grid. These point adjustment factors are then spatially distributed using an inverse-distance-weighting (IDW) algorithm. The resulting grid is then filtered to remove extraneous noise in the adjustment grid. The filtered adjustment grid is then multiplied by the original mean annual maxima grid to produce an adjusted PRISM mean annual maxima grid.

This simple approach allows fine-tuning of the PRISM mean annual maxima grid cell values, but it is not robust enough to accommodate new data points (i.e., stations not used in the original PRISM gridding), omissions of stations, or any major changes in the mean values. During the procedure, the software produces percent difference grids to evaluate differences between the previous grids and the adjusted grids.

During the last quarter, other spatial software, the Cascade, Residual Add-back (CRAB) derivation procedure, was modified to accommodate a conversion from AMS-based results to PDS-based results. AMS to PDS conversion factors will be calculated from the data for the final publication.

Finally, the software used to create vector (contour) shapefiles from the precipitation frequency grids was made more robust by incorporating logic to determine the best contour interval for the given grid. The software forces the number of contour intervals to be less than or equal to 30 and greater than 10. The contour intervals are forced to fall at convenient break points, yet provide as much spatial detail as possible.

3.4 Precipitation Frequency Data Server (PFDS)

The Precipitation Frequency Data Server (PFDS) underwent several modifications. In particular, the results provided by the PFDS will now be in terms of partial duration series, rather than annual maximum series, as the default. Results based on either series can be selected as a criterion from the state-specific web-page of the PFDS.

The state-specific input pages have been simplified by eliminating the radio buttons. The PFDS interface now detects which input type (via a click on the map, a click on a station, the pull-down list, static location, or by area) without the user having to indicate it.

In addition, reference information pages have recently been added. And we have also resolved legend color issues on the maps that we will be providing. A new color ramp was built to mimic the transparency color on maps.

3.6 Areal Reduction Factors

Progress continues in the development of geographically-fixed Areal Reduction Factor (ARF) curves for area sizes of 10 to 400 square miles. We have successfully completed testing and evaluation of the software through Chapter 5 of TR-24 by looking at the statistical results for Chicago, IL data. We are now working on the remaining chapters.

We have completed quality control on the data for Chicago, IL; Walnut Gulch, AZ; Tifton, GA; North Danville, VT; and Hastings, NE. Quality control work is continuing on the remaining study areas. We have added Riverside, CA and Maricopa, AZ to the list of areas we are studying. It is anticipated that a total of 15 study areas throughout the United States will be used in the study. The set of ARF curves developed for each study area will be tested for differences to determine if a single set of ARF curves can be used for the entire U.S. as is the case today or whether separate curves for different regions of the country are more appropriate.

4. Issues

4.1 Recent and Upcoming Presentations

Last quarter, Deborah Todd, representing HDSC, presented an update of the Ohio River Basin and Surrounding States Precipitation Frequency Project at the 83rd Ohio River Basin Commission Meeting in Lexington, KY on October 22, 2003.

Interest in the new estimates is increasing. As a result, Geoff Bonnin, representing HDSC, will give a presentation entitled Temporal Distributions of Heavy Rainfall Associated with Updated Precipitation Frequency Estimates at the Transportation Research Board Conference in Washington DC on January 15, 2004.

Geoff Bonnin will present "Recent Updates to NOAA/NWS Rainfall Frequency Atlases" at the American Association of Geographers Annual Meeting in Philadelphia, PA on March 18, 2004 and at the Southeast Region meeting of the Association of State Dam Safety Officers in Norfolk, VA on April 19, 2004.

He will also present a paper, "Statistics of Recent Updates to NOAA/NWS Rainfall Frequency Atlases," at the World Water and Environmental Resources Congress 2004 to be held June 28-July 1, 2004 by the American Society of Civil Engineers.

5. Projected Schedule and Remaining Tasks

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

> Data Quality Control [January 2004]
> L-Moment Analysis/Frequency Distribution [Complete]
> Spatial Interpolation [February 2004]
> Precipitation Frequency Maps [February 2004]
> Web Publication [March 2004]
> Spatial Relations (Areal Reduction Factors) [April 2004]

5.1 Data Quality Control

Remaining longer duration (>24-hour) 1000-year RDCs will be checked for data quality issues (see Section 3.1.2).

5.2 L-Moment Analysis

After any data corrections all L-moments and confidence limits can be easily and quickly completed.

5.3 Spatial Interpolation

After resolving the spatial bull's eye issues and addressing any remaining reviewer comments, HDSC will produce and send final mean annual maxima for all durations to be interpolated by Oregon State University using PRISM.

5.4 Areal Reduction Factors (ARF)

Software for the ARF computations will be completed in the next quarter and the computations will be performed for 15 areas. The resulting curves will be tested for differences to determine if a single set of ARF curves is applicable to the entire U.S. or whether curves vary by region.

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